The Frontlines: HSMM

Developments in Amateur Radio—Part I

In a nutshell, HSMM amateurs throw away the little indoor rubber-ducky antennas that come with the gear and replace them with outdoor antennas.

By John Champa,* K8OCL

In the previous issue of *CQ VHF* we discussed the basics of HSMM radio and how to get started. What is a ham to do with all this high-speed data capability? Let us now examine a few of the exciting new applications for HSMM radio in more detail.

If you read the Fall 2003 issue of *CQ VHF,* you already know that HSMM stands for High Speed Multi-Media radio networking. That is a mouthful, but nonetheless, it is not a specific operating mode, but rather a radio networking direction within amateur radio. Commercial folks often call this sort of radio *mobile computing.* The current developmental emphasis is on adapting to amateur radio use. The inexpensive, easy-to-use, commercial, off-the-shelf (COTS) microwave spread-spectrum digital packet-radio gear is readily available from most office and computer supply stores. This equipment is known in the commercial market as wireless local area network (WLAN) or WiFi gear. In a nutshell, HSMM amateurs throw away the little indoor rubber-ducky antennas that come with the gear and replace them with outdoor antennas. They set the gear for operations on the provided channels 2 through 5 and operate in the amateur radio 2.4-GHz band.

History

Amateur radio research into spread spectrum was started in 1981 by the Amateur Radio Research and Development Corporation (AMRAD) and continues to this day by organizations such as the Tucson Area Packet Radio (TAPR) group and the ARRL HSMM Working Group (http://www.arrl.org/hsmm/). The initial project was described in the May 1989 issue of *QST* and was reprinted in *The ARRL Spread Spectrum Sourcebook.* Current amateur research into spread spectrum can be found in the AMRAD and TAPR newsletters. Also, it is on the HSMM webpage noted above. A thorough explanation regarding how spread spectrum works can be found in the current edition of *The ARRL Handbook.* Because of the considerable research progress being made in this area by radio amateurs, the spread-spectrum portion of future editions of *The ARRL Handbook* will be revised considerably.

HSMM radio, although digital, is not primarily a keyboard radio communication medium, as in conventional HF and VHF packet radio. The throughput data rates in HSMM are significantly higher, typically 700–900 kbps or better, depending on the signal-to-noise ratio. These data rates are equal to 12 to 16 times faster than typical internet dial-up speeds (<56 kbps). At these high data speeds hams can operate two-way full-motion streaming video and audio called *amateur digital video* (*ADV*). ADV is about half the resolution or quality of a VHS tape, but it is still of sufficient quality for many image communication purposes.

Also used in HSMM radio is voice over IP (VoIP), which is the same technology currently used to carry voice traffic between linked FM repeaters over the internet. Even interactive e-game traffic is possible. HSMM radio is multimedia radio.

HSMM radio networks are not like other radio networks with which you may be familiar. Although round-table discussions are conducted, most operations of the HSMM radio local area networks are automated or semi-automated links, much like those experienced using TCP/IP over the internet; thus, the nickname of Ham + Internet = Hinternet. Accordingly, many HSMM stations are on the air continuously in an unattended mode of operation.

Remote-Control HSMM

Remote-control HSMM has some unique ham radio network applications and operational practices that differentiate the Hinternet from normal Wi-Fi hot spots, also known affectionately as Internet Cafes (Starbucks®, etc.). You may have read about these in the popular press. HSMM techniques are used for system RC (remote control) of amateur radio stations.

Time and Cost Sharing of Ham Stations

One of amateur radio's greatest challenges, particularly in high-density, residential areas, is constructing antennas, particularly high tower-mounted HF antennas, which work without inciting the entire neighborhood. Often, except for a few contest weekends or a band opening, these high-profile amateur stations are idle most of the time. They represent a significant investment in time and resources, and the burden could be shared easily. Implementing a portal to a remote HF station via 2.4 GHz is easy to do. Most computers now come with built-in multimedia support. Most amateur radio transceivers are capable of PC control. As you will further see in this paper, adding the 2.4-GHz networking is relatively simple. The only speed humps are getting the small 2.4-GHz antenna mounted outdoors (in deed-restricted communities), but such antennas are relatively small when compared to a full-

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size, three-element, 20-meter monoband Yagi on a 20-ft. high tower. Even high-gain ,2.4-GHz–band antennas such as the Comet® Model X2427 rated at 25 dBi, or the Diamond® Antenna Model 2400Y19 rated at 19 dBi gain, are small and unobtrusive. Here are the details on how one amateur radio operator, Darwin Thompson, K6USW, has done it with the Kenwood TS-480SAT/HX.

Kenwood recently introduced its new TS-480SAT/HX radio, which can be controlled over a LAN and the internet. After getting the radio, go to the Kenwood website and download the two programs for the TS-480SAT/HX (http://www.kenwood.net/indexKenwood.cfm?do=SupportFileCategory&FileCatID=3). The ARCP-480 is the radio-control software. The ARHP-10 is the radio host program. Follow the instructions included with the software to make the cables to interface the radio to your computer. With ARHP-10 running in the computer attached to the transceiver and the ARCP-480 running in a laptop PC with a microphone/earphone headset attached, you can control the radio and use VoIP on your HSMM radio station to transmit and receive audio, etc. It is as simple as that!

This system RC concept could be extended to other types of high-performance amateur radio stations. For example, HSMM radio can be used to link your current station or home office to a high-performance amateur radio VHF/UHF station, EME station, ATV station, or OSCAR 40 satellite ground station. These types of ham stations have large blocks of idle time and are ripe for the HSMM radio time-sharing experience. This could be done on a time-share and cost-share basis by the local amateur radio club or repeater group. The link would be back to members' homes, which do not allow, or simply can't afford, such large, complex, and expensive outside antenna arrays with associated high tower(s).

For more details on how this station remote control is easily done, see the article "Remote-Control HF Operation over the Internet" (or Hinternet, in this case), by Brad Wyatt, K6WR, on pages 47– 48 of the November 2001 issue of *QST*.

HSMM Surfing and Interactive E-Games

Sharing some high-speed internet access (Cable, DSL, WISP, or in the case of an amateur radio club or repeater group, perhaps a shared T-1 circuit) with another amateur is a popular application for HSMM radio. Over half the U.S. population is restricted to very slow dial-up internet connections (<56 kbps) over a plain old telephone service (POTS) line. Getting a high-speed internet connection, even a shared one, feels like you have discovered a new universe!

Note: If you use an HSMM microwave radio repeater (a.k.a. an AP) to share high-speed access to the internet, don't forget amateur radio content restrictions—e.g., no commercial for-profit business e-mails, etc. Don't worry about pop-up ads. Pop-up ads, although a nuisance, are no more illegal than, for example, an amateur television (ATV) station transmitting an outdoor scene and inadvertently picking up a billboard in the station camera, or your car AM/FM broadcast radio being heard in the background when talking on the local FM repeater. Such background sources are merely incidental to your transmission. They are not the primary purpose of your communications, plus they are not intended for rebroadcast to the public.

Do you have an old or a spare PC around? Use it as a server on your area HSMM radio network. Then it is possible to do things such as play interactive games, complete with sound effects and full-motion animation (see the Neil Sablatzky, K8IT,

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HSMM column in the Fall 2003 issue of *CQ VHF* for guidelines on using e-games on the air in amateur radio). This can be lots of fun and attract new club members. In the commercial world these are called WLAN Parties. For purposes of HSMM radio research, playing e-games is an excellent method of testing the true speed of your station's Hinternet link.

HSMM Radio in Emergencies

The HSMM radio driving force is Emergency Communications Support (RACES, ARES, etc.). Why are EmComm organizations so interested in HSMM radio capabilities?

1. They realize that the amount of digital radio traffic on 2.4 GHz is increasing and operating under unlicensed Part 15 power limitations cannot overcome this noise.

2. They need a high-speed radio network that can simultaneously handle voice, video, and data traffic for their emergency communications.

3. The cost of a commercially (government) licensed high-speed data network is more than they can collectively afford for use only during emergency conditions and exercises, which may be conducted only three to four times per year.

4. They also know that they continuously need to exercise any emergency communications system and have trained operators for the system for it to be dependable.

5. Amateur radio HSMM operations under amateur radio Part 97 regulations solve the problems of the above limiting factors. They can run more power than is allowed under Part 15 unlicensed operating, they have high-speed multimedia capabilities, they are cost effective (amateurs can do with $50K what Motorola can do for $250K), and they can be exercised daily or weekly by trained volunteer ham communicators doing what they do naturally.

Imagine being at an emergency scene and being able to send live video images of what is happening back to everybody on the HSMM microwave radio network using inexpensive web cams. The video could also be sent to an Emergency Operations Center (EOC), while at the same time submitting a written report (a long list of survivors, etc.) and simultaneously talking to the EOC using VoIP. Often all that is needed is an old or used laptop computer equipped with a wireless local area network enabled PC Memory Card International Association (PCMCIA) card with an external antenna jack. In HSMM jargon, such a card is called an RIC, meaning a radio interface card. Connect any of the small and inexpensive (about $20) digital cameras, or as an alternative, some Kodak and other consumer-grade digital cameras used for family snapshots also have a video output port. Then connect the RIC to a short Yagi antenna. Except for the RIC and the little antenna, many amateurs may already have all this gear!

In a recent *CQ* magazine survey ("What You Have Told Us," *CQ*, September 2003, p. 40) 8% of the respondents reported already using some kind of wireless networking, so there is already a growing understanding of the technology within the amateur ranks. Therefore, it is not difficult to put together an EmComm team and bring them quickly up to speed with HSMM radio (sorry for the pun . . . hi). While on the topic of speeds, here are some interesting findings from HSMM field experiments.

Data Rates: 802.11 links are essentially spread spectrum (see the Spread Spectrum topic in the chapter on Modulation types in any *ARRL Handbook*). It can provide fast internet-type speeds similar to a cable modem or DSL, even over many miles, provided that you have good antenna systems. The actual speed you obtain on your link will depend in large part on the signal-to-noise (S/N) ratio. The better the signal levels on the link, the higher the speed. The HSMM Working Group research has found that although manufacturers of 802.11b (DSSS modulation) equipment claim a maximum raw data rate of 11 mbps, and 802.11g (OFDM modulation) has a claimed maximum raw data rate of 54 mbps, the actual data throughput is significantly less. Why?

One reason you have already read about: As the signal-to-noise ratio declines, especially over the distance of many miles as experienced in the Hinternet, so does the data rate. However, there are other factors.

It should be noted that both approaches are radio, so they are either transmitting or receiving all the time, but not at the same time. They both use a collision-avoidance (CA) technique that results in half-duplex operation. Before transmitting, it listens to the channel first to make certain it is clear. That means the actual maximum theoretical data throughput is approximately half the data rate, or 5.5 mbps and 27 mbps, respectively.

In actual practice, we have found that with network overhead and other factors included, the real data throughput with maximum signal-to-noise ratio is approximately 3 mbps and 15 mbps, respectively. With a weaker signal, data rates will decrease even further. For example, my maximum data rate to my wireless internet service provider (WISP), called MediaNet® and 4.5 miles away, using 802.11b is approximately 900 kbps, more than 16 times faster than my old dial-up ISP.

Nonetheless, if more data throughput is needed for EmComm, etc., it should be possible to double those numbers. For example, an ARES amateur station might run the HSMM link using two access points (APs). One device could operate on channel 2 using a horizontally polarized antenna and the other on channel 5 using a vertically polarized antenna. Keep the antennas ten wavelengths apart (this is only about 40 inches on 2.4 GHz). It is certainly worth a try.

Amateurs Complete 82-mile Two-way DSSS Link on 2.4 GHz

While some of us complain of not being able to communicate from room to room with our wireless cards in our computers, ARRL HSMM Working Group Chairman, and *CQ VHF* magazine feature writer John Champa, K8OCL, reports that ARRL High Speed Multimedia (HSMM) Working Group member Ken Cuddeback, NT7K, and his students at Weber State University in Ogden, Utah recently completed two-way direct-sequence spread-spectrum (DSSS) communication on 2.4 GHz over a distance of 82 miles. The WSU students—including one ham, Brandon Checketts, KG4NZV, and several prospective licensees—broke the current world record of establishing a wireless link on 2.4 GHz with DSSS (using IEEE 802.11b WiFi protocol). Cuddeback reported that his students used PrimeStar dishes with unamplified Cisco Aironet 350 cards in each laptop. "We set up a NetMeeting session and transferred a 2.5 MB mp3 file successfully," he said. The Cisco WiFi cards run about 100 mW.

Portions of this report courtesy the *ARRL Letter* online edition, December 10, 2003 (http://www.arrl.org).

HSMM Radio Relay

When trying to extend the length of an HSMM link, the most obvious means would appear to be to run higher power and place the antennas as high as possi-

ble, as is the case with VHF/UHF FM repeaters. In both the U.S. and Europe there are several dramatic examples of this being done, single links extending 70 and 80 kilometers and more. This is the exciting approach often used by conventional microwave DXers, both amateur and commercial. Check out the great commercial photos and English text translation at this Polish website: <http://www.interline.pl/interline.php?s0=1&s1=1&s2=1&s00=1&s01=1&sx=2&s=czytelnia/110km>.

Even more impressive, an amateur radio operator and HSMM Working Group member leading a group of innovative students at Weber State University in Utah recently established a new HSMM radio world DX record. They are using standard wireless equipment (no amplifiers) and old modified satellite TV dish antennas (see sidebar).

As interesting and challenging as all this DXing with HSMM radio is, HSMM is network radio, and in some areas of the country taking this approach with 802.11, at least in the 2.4-GHz band, may cause some interference with other users. Other means of getting greater distances using 802.11 on 2.4 GHz or other amateur bands should be considered.

Many current HSMM networks are of relatively low-profile design. They depend on several low-power sources and radio relays of various types. For example, two HSMM repeaters (known commercially as access points [APs], about $100 boxes) may be placed back-to-back in bridge mode such that they simply will act as an automatic radio relay for the high-speed data. Using a series of radio relays of this or other similar designs on a string of friendly amateur towers, some great path lengths are possible. To encourage the amateur research and innovation in this radio-relay area, under consideration is an HSMM Radio Relay DX Award. The rules for such a competition might consist of merely measuring the maximum distance competing stations can retransmit or relay the entire contents of this article (including the photos) or a standardized video and audio clip. The actual data rate achieved could also be used to compute the scoring of points for the link. The primary stipulation, of course, would be that the entire path must be on the air. The possible use of high-altitude radio relays (balloons, rockets, and other experimental aircraft, etc.) may be permitted. However, no internet tunneling links (VPN) would be permitted for purposes of the award, although this is a common Hinternet practice for normal operations. If you are interested in such an award being developed, send me your ideas about how such a contest might be conducted. If enough interest is shown, a sponsoring organization such as this magazine or the ARRL will be approached to establish some contest guidelines.

In Part 2 (HSMM Operations) and Part 3 (Hinternet Infrastructure) of this series we will discuss some other considerations in HSMM radio:

- HSMM Area Surveys
- HSMM Antenna Systems
- Running higher power
- Information Security
- HSMM frequencies
- HSMM on 900 MHz, 3.5 GHz, and 5 GHz
- Proposed HSMM Network Infrastructure
- HSMM Interface with ICOM D-STAR systems
- Recommendations

For complete details on the many sources and types of inexpensive gear and antennas to get started in HSMM radio, see "How To Get Into HSMM," pp. 30–36 in the Fall 2003 issue of *CQ VHF*, and check out <http://www.arrl.org/hsmm/>.

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The Frontlines: HSMM

Part 2 – Developments in Amateur Radio

One of the major advantages of operating 802.11 under Part 97 rather than Part 15 regulations is the feasibility of operating legally with more RF power output and larger, high-gain directive antennas.

By John Champa,* K8OCL

In the Winter 2004 issue of *CQ VHF* we reviewed some of the many current and proposed applications of High Speed Multi-Media (HSMM) radio networking. Let's now move on to examine the operational aspects of the HSMM state-of-the-art.

HSMM Area Survey

It is important to find out what other users of the band, both licensed amateurs and unlicensed (Part 15) stations are doing in your area before designing your community HSMM radio network. This would be tough to do on 2 meters FM using a simple scanner receiver, as most repeaters are not transmitting most of the time. However, on HSMM it is very simple! All active repeaters (APs) are constantly sending out a beacon known commercially as the ESSID. In HSMM practice this is simply the ham station callsign (and perhaps club name) entered into the software configuration supplied with the CD that comes with the repeater. Thus, every HSMM repeater is also a continuous beacon.

As a minimum evaluation, a simple local area survey using free NetStumbler software (http://www.netstumbler.com/index.php) downloaded and running on your laptop PC should be conducted. Connect one of the popular 2.4-GHz mobile magnetic-mount vertical antennas to a pigtail. Connect the pigtail to your radio interface card, or RIC (that is the wireless PCMCIA card with external antenna port[s] which can be purchased at most office-supply stores for about $80). Insert the RIC into the laptop (after loading its software), and the laptop into your dashboard power plug. You can also interface your GPS with mapping software into your laptop so as to provide a map of the area signal sources (see samples in the following links: <http://www.techtv.com/news/internet/story/0,24195,3398350,00.html> and <http://www.windley.com/2002/09/02.html>).

Drive around your community. Better yet, let your XYL or ham friend operate the vehicle while you operate the HSMM area survey gear. That is a safer approach. This methodology will at least identify and automatically log what other 802.11 station activity is in your area. Note that when planning your HSMM operating, even moving two to three channels away from such activity may not be sufficient to avoid interference, especially if you are running what in HSMM is considered high power (typically 1800 mw RF output). You may want to use a different polarization with your antenna system. For example, many HSMM stations use horizontal polarization, because much WLAN activity is vertically polarized.

If you have access to a private aircraft, you might even try doing the area survey from the air! As mentioned in the previous article, many HSMM radio amateurs use 446.00-MHz FM for voice coordination, but any clear FM simplex channel will work for this purpose.

HSMM Radio Antennas

Horizontal Polarization: As mentioned previously, most of the unlicensed implementations of 802.11 equipment use vertically polarized antennas, so in many locations amateurs may find that the use of horizontally polarized antennas is helpful in avoiding interaction. Again, an HSMM area survey is highly recommended.

Space Diversity: Another aspect of HSMM antenna design that warrants further amateur radio experimentation is space diversity. Some APs already have this capability built in; it simply is seldom used on outdoor links. The APs come with two rubber-ducky antennas and two antenna ports, a primary and secondary. Which signal input is used depends on which antenna is providing the best signal-to-noise (S/N) ratio at the specific instant. Experimentation using two outside high-gain antennas spaced ten or more wavelengths apart may be worthwhile in improving data throughput on long links, which tend to experience more multi-path signal distortion. This multi-path effect is caused by multiple signal reflections off various objects in the path of the linking signal. The use of space-diversity techniques may help ameliorate this effect and improve the data rate on the link.

Circular Polarization: One would think that two OSCAR-40 stations with patch-fed circularly polarized antennas on 2.4 GHz and in close proximity to one another would be in an excellent position to experiment with circular polarization using HSMM techniques. However, most OSCAR-40 stations have a good deal of non-related electronics at or near the feed point of their 2.4-GHz downlink antenna, such as one-way low-noise receive pre-amplifiers, 2.4-GHz to 144-MHz receive converters, etc., which make them unsuitable for such testing without some extensive rewiring or switching. Nonetheless, the use of circular polarization created by the same means (see below) at both ends of the

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link, and its ability to enhance propagation of HSMM radio signals, warrants further study by radio amateurs.

Mixed Antenna Design Problem: This is the possibility of a unique situation when using HSMM radio with certain antennas which requires more amateur radio study. It is often thought that as long as both antennas at the ends of an HSMM radio link are of broad-bandwidth design (the HSMM signal is 22 MHz wide) and of the same polarization (usually horizontal) then this is acceptable and all is okay. While this may be true for other wide signals, such as analog ATV VSB (vestigial sideband) signals or analog ATV-FM signals, it may not be true with even more broad-bandwidth high-speed digital signals. Some evidence seems to indicate that, for example, the use of a horizontally polarized dish antenna with a dipole feedpoint at one end of the link and the use of a horizontally polarized long loop Yagi at the other end (again both broad-bandwidth antennas and both horizontally polarized) may nonetheless introduce a problem (higher BER, or bit error rate) because of symbol errors caused by the manner in which each antenna manipulates the radio-signal wave front. Again, further radio amateur experimentation with HSMM radio signals is warranted to determine the impact of using mixed antenna types on the radio link.

Running Higher Power

One of the major advantages of operating 802.11 under amateur radio Part 97 regulations rather than unlicensed Part 15 regulations is the feasibility of legally operating with more RF power output and larger, high-gain directive antennas to further increase the effective radiated power (ERP). Using the minimum power necessary for communications has always been a good operating-practice guideline for hams. However, the use of higher ERP makes for more robust signal margins, which may be required to achieve certain emergency communications objectives.

Using higher output power in HSMM radio, especially on the shared 2.4-GHz band, is also a last resort for other reasons. Amateurs should try using more directional and higher gain antennas instead of running more power output whenever more robust links are required for EmComm operations in support of RACES, ARES, etc. It is best to run the minimum power needed to maintain the communications, and we also must be considerate of others who may be using the band, both amateur and non-amateur. Use only the minimum power needed for the link.

If the HSMM radio link analysis (see the link calculations portion of <www.arrl.org/hsmm/> or go to <http://logidac.com/gfk/80211link/pathAnalysis.html>) clearly indicates that additional power is required, then what may be needed is a bi-directional amplifier (BDA). This is a super-fast switching pre-amplifier/amplifier combination that is usually mounted at the end of the antenna pigtail near the top of the tower or mast. A reasonably priced 2.4-GHz, 1800-mw output BDA is available from the FAB Corporation (www.fab-corp.com). It is designed specifically for HSMM microwave amateur radio experimenters. (*Note:* Be certain to specify "HSMM" when placing your order!) This additional power output should be sufficient for nearly all amateur operations, even those supporting EmComm which may require more robust signal margins than normally needed by amateurs. Please note that because of strict Part 15 regulations prohibiting the use of such devices by unlicensed individuals, a copy of your amateur license may be required when placing your order and the shipment may only be made to your license address in the FCC database.

Other High-Power Considerations: When using a BDA and operating at higher than normal power levels on some of the lower channels in the 2–5 channel range (these channels are arbitrary channels for Part 15 operation and are not required for amateur radio use, but they are hard-wired into the gear, so we are stuck with them), if your station is next door to an OSCAR 40 station, you may need to take extra steps in order to avoid interfering with the weak downlink signal from the satellite. Even when totally avoiding the use of channel 1 (center frequency of 2412 MHz ±11 MHz), 802.11 does have signal sidebands. The use of an output filter may be required to avoid causing QRM to the amateur satellite downlink. On the other hand, when operating in the upper channels in the 2–5 channel range and using high power, some of your sidebands may go outside the amateur band, which stops at 2450 MHz. From a practical point of view, whenever using a BDA, it is good practice to install a tuned filter on the BDA

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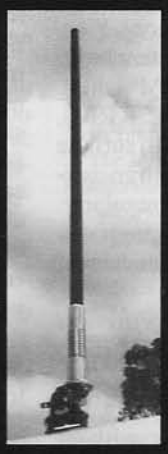

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output. Such filters are not expensive and they are readily available from commercial sources.

In addition, if interference to the OSCAR-40 downlink station is a problem, keep in mind that the hours of OSCAR-40 availability can readily be predicted and a cooperative schedule of operating can be developed. Amateurs living close by frequently do this type of coordination on the HF bands. Again, an inexpensive low-power transceiver left on continuously and monitoring 446.00-MHz FM simplex is a handy approach to facilitate such HSMM coordination.

There is one further point to consider: Depending on what other 802.11 operating may be taking place in your area, it may be practical to only run higher power when using highly directional antennas which allow operating over and around the Part 15 activity in your area. Before considering running higher power, again, it is highly recommended that an area site survey be conducted using a mobile HSMM rig (laptop + RIC + pigtail + 2.4-GHz magnetic-mount antenna) running NetStumbler software (www.netstumbler.com) or other wireless sniffing software. This area survey will allow you to determine what 802.11 activity is in your area and what channels are being used and at what ranges from your station. This information will help you avoid any interaction with them.

Information Security

When operating HSMM radio, your station and your computer become one single device, much as in the case of software-defined radio (SDR). Amateurs in general are the finest folks you might ever meet, but there are a few exceptions. Plus, there are others who are not amateurs who may try to hack into your HSMM station. Thus, each HSMM station (PC + RIC), as is the case with any PC used to surf the Internet, should be equipped with an *anti-virus program* that is updated regularly. Reasonably priced anti-virus programs are readily available from number of sources.

It is very important is to use a *firewall* software program on your HSMM radio station PC. We recommend that it be configured to allow all outgoing traffic, but to restrict all incoming traffic without specific authorization. Commercial personal firewall products are available from Symantec®, ZoneLabs®, and McAfee Network Associates®. Here is a link to a list of freeware personal firewalls: <http://www.webattack.com/freeware/security/fwfirewall.shtml>. A list of shareware personal firewalls may be found at: <http://www.webattack.com/Shareware/security/swfirewall.shtml>.

HSMM Microwave Radio Frequencies

What frequency do you set on the AP?

Where *not* to go: The HSMM Working Group (WG) recommends to everyone—all users, both licensed and unlicensed—that they avoid using channel 1 (center frequency of 2412 MHz). Use of this channel may cause interference to the AMSAT OSCAR-40 satellite downlinks in the immediate area.

The WG also recommends that amateur radio stations avoid the use of channel 6 (center frequency of 2437 MHz). This is the most common default frequency used by the majority (>80+ %) of Part 15 unlicensed stations for wireless local area networks (WLAN). Although the center frequency of channel 7 (2442 MHz) is within the amateur band, remember that 802.11 spread-spectrum modes are 22 MHz wide, so part of the signal would fall outside the amateur band.

At present, that leaves channels 2, 3, 4, and 5 as acceptable for amateur radio HSMM experiments. Which specific channel you select depends on other activities in your area. You need to consider OSCAR-40 stations, FM-ATV, WISP (wireless internet service providers), your neighbor's WLAN, and others users of this shared band. The most popular frequency used by U.S. amateur radio microwave stations for HSMM research is 2427 MHz (channel 4). However, keep in mind that the spread-spectrum signals are 22 MHz wide. This does not include the sidebands, which are considerable. Most of the inexpensive 802.11 gear is unfiltered, so it has rather considerable sidebands. If you live in the country, this may not make any difference. However, if you live in a congested urban area, you need to remember that while the channels are only 5 MHz apart, the channel signal with its sidebands is much wider. Again, an area survey prior to starting up is highly recommended. Find out what other users of the band are in your area. As mentioned previously, because of the sidebands associated with unfiltered spread spectrum, even moving to channel 4 may not guarantee that you don't QRM your OSCAR-40 neighbor, so you may also need an output filter. If you don't have access to a spectrum analyzer for your area survey, then at least do an area survey using an appropriate RIC, your best directional antenna, and NetStumbler software, as described previously, before choosing an operating channel.

HSMM on the 900-MHz, and 3.5- and 5-GHz Ham Bands

Now available are relatively inexpensive commercial converters and amplifiers which will convert 802.11 signals on 2.4 GHz to the amateur 900-MHz and 3.5-GHz bands (see: <http://www.teletronics.com/tii/products/udc/udc_table.html>).

The 900 MHz amateur band (see the PDF on the RFLinx website <http://tinyurl.com/vtx6> for details) should offer ranges and signal propagation more similar to what hams experience on the 440-MHz band. However, the 900-MHz amateur band provides only one channel, but at least it is away from the vast majority of Part 15 traffic. This may be the best band to use to provide inter-city links on the Hinternet. Comtelco® is one source of 900-MHz antennas (http://www.comtelcoantennas.com/index.htm). Again, more HSMM radio amateur experimentation is warranted.

The 3.5-GHz amateur band will get HSMM entirely out of the frequency range of all Part 15 traffic, but should have similar ranges and signal propagation when compared to the 2.4-GHz band. Again, further HSMM radio amateur experimentation on this band is encouraged.

The 5.0-GHz amateur band may be a good band to use for HSMM in some areas. There will be significantly less Part 15 traffic on this band, but ranges may be slightly less than on 2.4 GHz.

In Part 3 (Hinternet Infrastructure) of this series we will discuss some other considerations in HSMM radio:

- Proposed HSMM Network Infrastructure
- HSMM Interface with ICOM D-STAR systems
- Recommendations

For complete details on the many sources and types of inexpensive gear and antennas to get started in HSMM radio, see *How To Get Into HSMM,* pp. 30–36 in the Fall 2003 issue of *CQ VHF,* and check out <http://www.arrl.org/hsmm/>.

The Frontlines: HSMM

Developments in Amateur Radio – Part 3

What is this nationwide high-speed network via amateur radio? What do hams envision in the Hinternet? Read on to find out.

By John Champa,* K8OCL

In the Winter 2004 issue of *CQ VHF* we discussed High Speed Multi-Media (HSMM) applications (Part 1 of "The Frontlines") and in the Spring 2004 issue we covered operational considerations (Part 2). In this concluding part we will now look into our crystal ball and try to predict how the proposed HSMM Network Infrastructure (also affectionately know as the *Hinternet*), may emerge in the 21st century.

Proposed HSMM Network Infrastructure

The HSMM Working Group is following a systems engineering approach toward the development of a nationwide amateur radio HSMM digital network, as directed by its ARRL charter. Why?

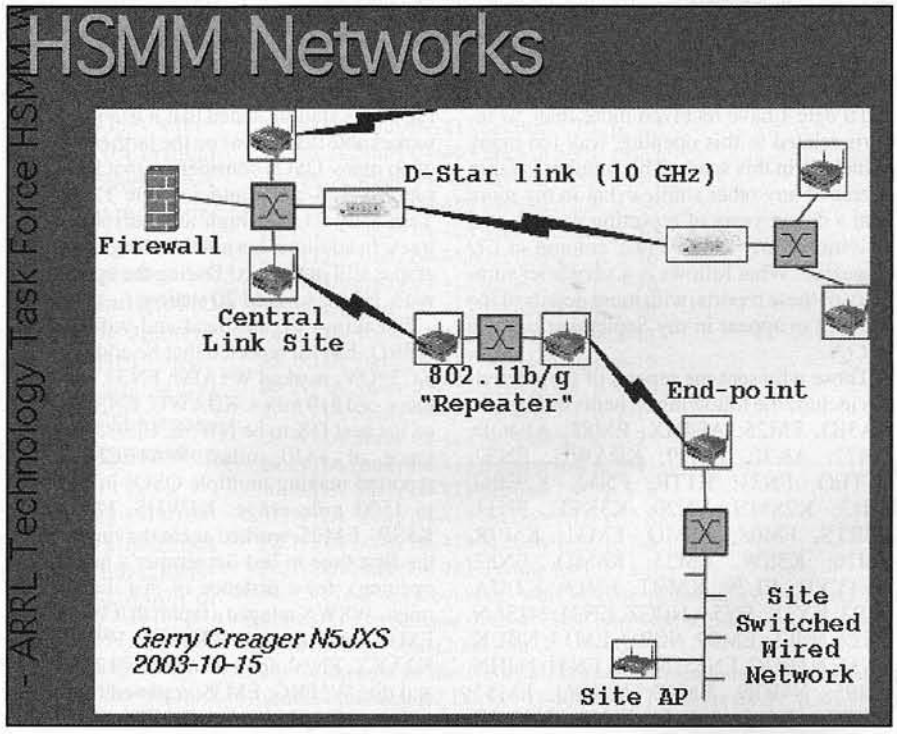
The existing amateur radio data networks primarily consisting of 1200- and 9600-baud AX.25 packet radio are becoming totally inadequate to meet the growing requirements of modern mobile computing applications for the following reasons:

- Insufficient spectral efficiency—multiple users cannot simultaneously use the same frequency.
- Excessively slow data rates —far less than even the typical Internet dial-up speed of <56 kbps.
- Very limited linking capabilities—communication should be possible with any station on the air and on the network (or Hinternet, in this case) regardless of location.
- No combined, simultaneous data *and* voice *and* video capabilities.

Although the initial draft of the Hinternet has not yet been approved by the HSMM Working Group and subsequently opened for public comment, we can discuss some of its planned key provisions. Essentially, the Hinternet is intended to be similar to the Internet, but entirely (or at least primarily) for amateur radio.

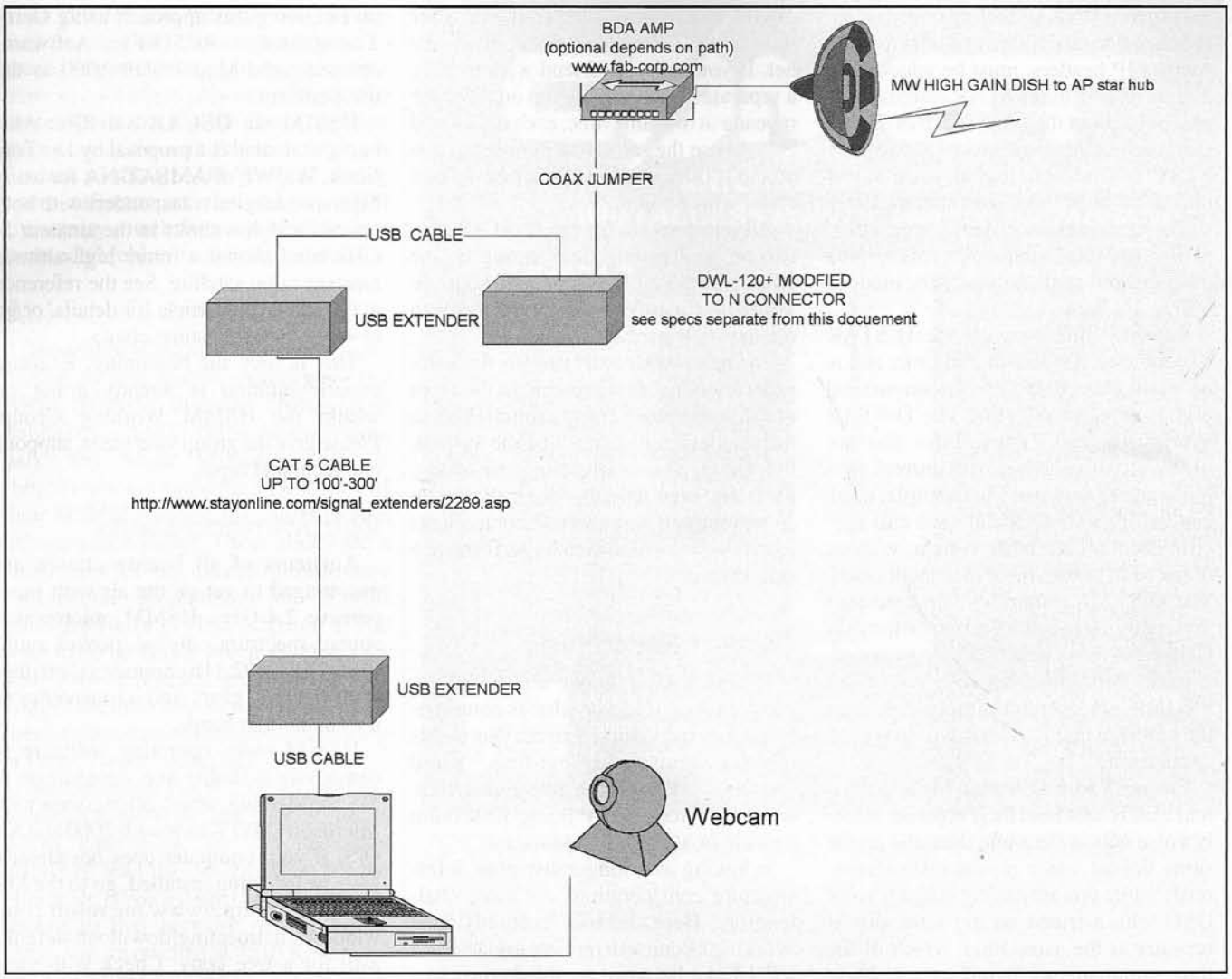
One key element of the infrastructure specification and design is linking fixed EmComm sites in a metropolitan area which will be utilized in emergency settings by radio amateurs. This entails fixed path links, accessible solely by the target endpoints.

Another element of the infrastructure planning is creating an integrated network of these point-to-point links so that they are useful. Having a link between two sites is wonderful, but not too useful when there are 20 sites that need to communicate. To achieve this linking, the Working Group anticipates using conventional Ethernet switches (not hubs!) to interconnect the wireless devices at node points, and incorporate good RF practice in spatial and frequency diversity (different channels, changes in polarization, good horizontal and vertical separation) to achieve multiple links from a single site. One consideration in *all* of these links: The Working Group is rec-



A basic amateur radio HSMM network. It envisions multiple linked HSMM repeaters or access points joined via a smart mesh network to form what is called an HSMM Radio Metropolitan Area Network, or simply an RMAN. Various approaches are being investigated by radio amateurs to provide such links, including ICOM D-STAR, IEEE 802.16, and Virtual Private Networks (VPN) over the wired Internet.

**Chairman of the ARRL Technology Task Force on HSMM Radio Networking; Moon Wolf Spring, 2491 Itsell Road, Howell, MI 48843-6458; e-mail: <k8ocl@arrl.net>*



A typical Amateur Digital Video (ADV) station complete with cost estimates. We call this ADV to distinguish it from ATV. They both are excellent forms of amateur radio visual or image communications. However, depending on your base station, the HSMM approach is a less-expensive communications-grade video because of our use of software coders and decoders such as are found in Video-over-IP or streaming video technologies (H-323) coupled with inexpensive web cams. (Drawing by Jim Markstrom, KB9MMA, and courtesy of the Racine-HSMM Group)

ommending high-gain, dish-style grill antennas rather than omni-directional antennas at the node sites. These antennas are readily available for less than $100 including shipping and handling, with antenna gains in excess of 20 dBi (http://www.fab-corp.com/). Both horizontal and vertical polarizations are available from most manufacturers.

D-STAR®

Other alternatives for HSMM links, such as high-speed packet (56 kbps, or modem speeds) or the ICOM D-STAR® system on both the 1.2- and 10-GHz bands, might serve well.

D-STAR is a complete end-to-end, high-speed networked amateur radio data system that also provides digital voice over its backbone. The system uses 1.2-GHz transceivers and repeaters, and it has many advantages over analog systems. Hams familiar with computer systems and Internet-linked voice systems will be at ease with the D-STAR system, as it incorporates many of the existing features, as well as many new and advanced features not previously seen in amateur radio, but common on commercial digital repeater systems.

The high-speed data features in the D-STAR system were designed for mobile applications. While 802.11 can provide higher speed data, and it is frequently used from stationary mobile vehicles, it is not optimized for mobile applications when picket-fencing and multipath effects occur. The data rate of the D-STAR system is 128 kbps. This is still roughly three times faster than current dial-up technology. This is more than enough speed to allow hams to browse the Internet, send e-mail, and download files. Just as in other areas of the Hinternet, all of the applications that can be run on a home computer system can be run on D-STAR.

The D-STAR system also incorporates digital voice using the AMBE 2020 vocoder. This provides a very efficient occupied bandwidth of only 6.25 kHz. D-STAR digital voice is more efficient than compressed digital voice (G.711, G.722, or G.728) commonly used in 802.11 HSMM radio VoIP communications. VoIP is good for compatibility and it is

easy to use (MS NetMeeting), but it is less efficient because additional information, such as IP headers, must be added. The digital voice in the D-STAR system occupies only about the same space as double sideband. In this bandwidth space the D-STAR is sending a digital voice signal plus a 2.4-kbps serial data stream. Users could send packet or APRS type information in this bandwidth space, plus other custom applications can be made to utilize this data.

Repeater linking with the D-STAR system uses 10-GHz digital links and is on par with contemporary, commercial digital repeater systems. The D-STAR system has many capabilities that are practically impossible with current analog repeater systems. For example, users can link repeaters, or they can call specific users on a remote system, without the need to know where they are located. The D-STAR system will find the user you are trying to call based on the last 1.2-GHz repeater system the user accessed. If a user is roaming between systems or traveling, an operator simply can input the call sign and D-STAR will make the connection.

Future Exam Question? If two amateur radio clubs hold their separate weekly voice nets at the same time and on the same digital voice repeater simultaneously while you are having a digital voice QSO with a friend on the same digital repeater at the same time, which of the three simultaneous digital voice conversations would a transceiver monitoring the digital repeater's output signal hear?

Answer: It all depends on which digital code was entered into the monitoring digital transceiver. If your radio club's digital voice code is entered into your transceiver, you will only hear that voice net. If you and your friend wish to have a separate side-conversation on the same repeater at the same time, each of you will have to use the same voice code, but one which is different from either of the two clubs' voice codes.

All components for the D-STAR system are undergoing field testing by the ARRL and TAPR. They will soon be available for users in complete form in off-the-shelf packages.

For hams who still want to do some experimenting, it is possible in the form of software enhancements and changes to the standard user control of the system. For those who really enjoy tinkering, users are even able to design their own software interfaces and add components to the system to enhance its performance and features.

Other Alternatives

Wired Links: Other alternatives—such as using IPsec or what is commonly known as Virtual Private Networks (VPNs) across the existing, wired Internet—offer routine interconnection, while not necessarily being EmComm capable or acceptably redundant.

In linking over longer distances, infrastructure considerations are more challenging. Here, almost certainly, the Working Group will recommend Internet VPN links between established metropolitan networks.

HF High-Speed Links: The Working Group is also investigating the use of the HF bands for links. The HSMM-HF Project, led by Neil Sablatzky, K8IT, is investigating this approach using Gerry Youngblood, AC5OG's software-defined radio Model SDR-1000 as the test platform.

HSMM via OSCAR Satellite: Also being evaluated is a proposal by Dr. Tom Clark, W3IWI, of AMSAT-NA for using high-speed digital transponders with both uplinks and downlinks in the amateur 5-GHz band aboard a future high-altitude amateur radio satellite. See the reference at the end of this article for details, or go to <http://www.gpstime.com/>.

This is only the beginning. Exciting experimentation is already going on within the HSMM Working Group. Please give the group your ideas, support, and technical input.

Recommendations

Amateurs of all license classes are encouraged to get on the air with inexpensive 2.4-GHz, HSMM, microwave, spread-spectrum, digital packet radio using IEEE 802.11b commercial off-the-shelf (COTS) gear. Add a transverter to try out another band.

HSMM radio operating software is commonly available free. An example is MS NetMeeting, which often comes with Microsoft (MS) Windows® 2000 and XP O/S. If your computer does not already have NetMeeting installed, go to the MS website (http://www.microsoft.com/windows/netmeeting/download/default.asp) for a free copy. Check with your local HSMM radio group. They may be using different free operating software such as OpenH323 using Linux.

A soundcard is already built-in with most PCs. Plug your headset into that soundcard using, for example, a $15 headset from RadioShack® (the typical laptop PCs have poor speakers and microphones, plus it is sometimes difficult to hear a laptop clearly if there is noise in the area). Then add an RIC ($85) and a suitable strain-relief cable or pig tail ($15), and any external outdoor 2.4-GHz antenna. Want to do ADV? Add a webcam ($20) to your PC, or interface your existing digital-camera video output port. It is an easy, extremely low-cost way to do microwave radio voice, video, and high-speed data (a.k.a. multimedia) experimenting.

For complete details on the many sources and types of inexpensive gear and antennas to get started in HSMM radio, see *How To Get Into HSMM,* pp. 30–36, in the Fall 2003 issue of *CQ VHF,* and check out <http://www.arrl.org/hsmm/>.

Recommended Further Reading on HSMM Microwave Radio Networks

Building Wireless Community Networks, by Rob Flickenger, a member of the ARRL HSMM Working Group. The 2003 Second Edition is recommended.

Proceedings of the AMSAT-NA 21st Space Symposium, November 2003, Toronto, Ontario, Canada, especially the paper by Tom Clark, W3IWI, "C-C RIDER, A New Concept for Amateur Satellites."

Both of the above excellent publications may be purchased from: ARRL Publication Sales Department, 225 Main Street, Newington, CT 06111-1494; toll-free U.S. 1-888-277-5289, outside the U.S. +1-860-594-0355; <http://www.arrl.org/catalog/cathelp.html>.

It has been suggested that many amateurs may need to enhance their networking skills. The following books will make upgrading networking knowledge easier than the average technical or engineering textx on the subject:

Ivens, Kathy and Larry Seltzer, *Linksys Networks: The Official Guide,* McGraw-Hill 2002.

Danda, Mathew and Heather T. Brown, *Step by Step: Home Networking with Microsoft Windows XP,* Microsoft Press 2001.

Gilster, Ron and Diane McMichael Gilster, *Build Your Own Home Network,* McGraw-Hill 2000.

As you can see, there are a lot of initiatives going on on several amateur radio bands. Experimenting with local connectivity at 2.4 GHz is only one of them. For more details and for the latest developments on all these initiatives, check out the link to the HSMM Working Group open reflector at the Texas A&M University website: <http://listserv.tamu.edu/archives/arrl-80211b.html>.

Acknowledgements

The author wishes to express his appreciation to two special members of the ARRL HSMM Working Group, Neil Sablatzky, K8IT (http://www.hsmm.us/), and Mark Williams, AB8LN (http://www.qsl.net/ab8ln), for the use of their HSMM frequencies and Hinternet infrastructure slides. These slides are a small part of an excellent full-range PowerPoint presentation on HSMM radio that Neil and Mark prepared. If you wish to do an HSMM demonstration for your club or repeater group, a full free copy of the most up-to-date version of the presentation is available for downloading at <http://www.hsmm.us>.

Also, thanks to Gerry Creager, N5JXS, a research network engineer at Texas A&M University, for his dedicated efforts to lead the design effort for the Hinternet. If you wish to comment or contribute to this network design effort, Gerry can be reached at 8610 Rosewood Dr., College Station, Texas 77845-5594; e-mail: <n5jxs@tamu.edu>.

Information on the ICOM D-STAR System was courtesy of Matthew F. Yellen, KB7TSE, Technical Sales Specialist, D-STAR, ICOM America, Inc., Bellevue, WA 98004; telephone 425-450-6045; fax 425-454-1509; <http://www.icomamerica.com>.

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Finally, I would like to express my warm appreciation to my beautiful and loving XYL, Karen Feder, art teacher extraordinaire, for all her patience during this writing and research. ■

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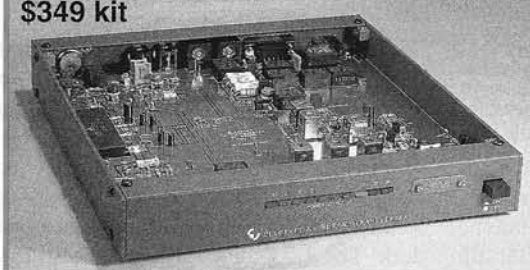

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